ENGINEERING RESEARCH INSTITUTE
UNIVERSITY OF MICHIGAN
ANN ARBOR

QUARTERLY TECHNICAL STATUS REPORT

September 15, 1953 to May 31,1954

submitted by

Otto Laporte
Professor of Physics

Project 2189

AIR RESEARCH AND DEVELOPMENT COMMAND, U.S. AIR FORCE
CONTRACT AF 18(600)-983, PROJECT R-357-40-6

June, 1954

QUARTERLY TECHNICAL STATUS REPORT

INTRODUCTION

Luminosity was first observed in the University of Michigan two- by seven-inch shock tube in April 1952 in connection with the study of moderately strong shock waves.[1] At that time a brief but intensive preliminary investigation was made and the results reported by Professor Otto Laporte, principal investigator of this project, to the Fluid Dynamics Division of the American Physical Society at Salt Lake City in June 1952. Later these results were published in a Letter to Nature.[2]

Because of the interesting possibilities suggested by this phenomenon, it was decided to construct a smaller and stronger shock tube designed expressly for the production of very strong shock waves.[3] For this purpose, two-thousand dollars was made available by the University of Michigan in August 1952. However, because the project personnel were previously committed to other work, work on the small shock tube was not begun until the spring of 1953. The sections of the tube, together with the vacuum plumbing, were completed in September of that year with University funds. During this time, negotiations were under way for the present Air Force contract, and the project was finally set up on November 30.

EQUIPMENT

The photographs of the shock tube included at the end of this report show the pressure and vacuum plumbing, gauges, and the prism spectrograph pointed toward the window at the end of the tube. The high-pressure

---

[1] The pressure ratio across the shock waves was 15-20

[2] Nature, 171, 395 (1953)

[3] The old shock tube of two-inch by seven-inch cross section was built primarily for aerodynamic studies and was not capable of withstanding the high pressures or reaching the high vacuum necessary for the production of very strong shock waves.

chamber, built to withstand 2000 psi., is at the right. The vacuum system includes an oil diffusion pump which can evacuate the low pressure chamber to less than one micron absolute pressure; since only a few millimeters of mercury pressure of rare gases are usually used, the purity of these gases is insured.

RESULTS

When the tube was first fired in January of this year, a two-prism spectrograph[4] was set up to observe the luminosity in the tube. The resulting flash of light was far more brilliant than any seen previously in the old two-inch by seven-inch shock tube. As the reproductions on pages 4 and 5 show, the spectra contained a wealth of metallic lines, of lines of the carrier gases (argon, or xenon), and a very prominent continuous background. As the shock strengths become greater, the emission lines are gradually submerged in the continuous background. Most striking is the spectrogram taken with neon gas which exhibits the hydrogen lines H_β, H_γ, H_δ as impurities. The hydrogen lines exhibit a considerable first-order stark effect by being broadened to a half-width of as much as 80Å, while the neon lines remain comparatively sharp. Except for the fact that all shock tube spectra are emission spectra, they are quite similar to the absorption spectra observed for stars of class A or B. Indeed, this work has created considerable interest among astrophysicists here at the University and elsewhere.

FUTURE PLANS

Except for the successful construction of the shock tube and the obtaining of numerous but as yet primitive spectrograms, the work is still

---

[4] Property of the University of Michigan light laboratory

in the preliminary stage. It is intended to investigate the following topics in more detail:

(1) High temperature hydrodynamics. The standard theory for shock flow has to be altered profoundly due to the fact that a large percentage of the gas atoms behind the shock will be ionized. In other words, the passage of the shock through the gas is accompanied by what might be compared to a chemical change, in view of the circumstance that the material behind the shock now consists of three different kinds of gases: a) neutral atoms b) ionized atoms c) free electrons. The investigation of this phenomenon will have to proceed on the one hand experimentally, that is to say, towards the observation of the flow variables, and on the other hand, theoretically; namely, toward the calculation of an equation of state and of Rankine-Hugoniot curves. For the observation of flow variables a revolving drum camera, now under construction, will be used to measure shock velocities. Also electromagnetic measurements with the variable-volume cavity formed by the tube and the approaching shock are contemplated. The theoretical work, while in principle fairly clear cut, seems very involved and may necessitate the use of a high speed computer.

(2) The influence of high densities upon light emission. Light emission at high gas and electron pressures makes itself felt in the broadening and red shift of the spectral lines briefly referred to above. A detailed exploration of this phenomenon should be of greatest value to astronomers and will give interesting new information on the interaction of elementary particles. In order to investigate the temporal relations between light emission and broadening, it is intended to employ time-resolved spectroscopy, which can be done by photographing the spectral lines by means of the previously mentioned drum camera.

Note: For the four pages of photographs refer to file copy.